General Guidelines for Hydrogeological Investigations

Land and Water Management Division
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Some of the permits issued by the DEQ's Land and Water Management Division (LWMD) may require the applicant to perform a hydrogeological investigation. Some examples of where this may be needed are excavations for gravel pits or man-made lakes, re-routing streams or drains, analyzing impacts to wetlands, and determining whether a wetland is hydrologically connected to surface water bodies or groundwater. These types of projects may alter the local hydrologic conditions either by diverting water, changing the groundwater level and flow direction, or impacting water quality. It may be necessary, before permits are issued, to determine existing hydrologic conditions at the proposed site and to assess whether adverse environmental impacts could occur if the proposed project was completed. In order to document these conditions or assess possible impacts, it is necessary for the permit applicant to complete a hydrogeologic investigation prior to beginning any on-site development or issuance of a permit by the LWMD. This document should be used as a guide to gathering the needed data and assessing the impacts.

There are different levels of investigation required that are dependent upon site features such as: location in a watershed, proximity of existing surface water bodies, site hydrology, local geology, and local land use. Some of these features are readily discernible; others, such as geology, are not. The following is a suggested sequence of work that may be followed by a permit applicant to investigate conditions at their site.

1) **Site and Project Description**

a) Prepare a map showing the regional setting. At a minimum, the map should cover an area with a one-mile radius measured in all directions from the center of the property. If the size of the project is large, it may be appropriate to increase the geographic area covered by this map. The site location map must show the following features in a clean, legible manner:
   - Proposed limits of excavation
   - Scale and north arrow
   - Section lines and numbers
   - Township and range numbers
   - Township name
   - Location of all existing lakes, streams, drainage ditches, and apparent wetlands within the geographic area covered by this map
   - Boundaries for the property where the proposed project will occur

b) Prepare a detailed site map that covers an area that extends at least 1000 feet beyond the property boundaries of the permit applicant. This map should show:
   - Scale and north arrow
   - Property boundaries
   - Boundaries and owner names for all adjoining land parcels
   - Location of all existing lakes, streams, drainage ditches, and apparent wetlands on-site and within 1000 feet of the property boundaries
   - Delineated wetlands expected to be impacted by the project
   - Location of proposed project
   - Land surface elevations for the property shown by appropriately selected contour intervals
   - Water surface elevation for all existing lakes, streams, drainage ditches, and wetlands located on-site and within 1000 feet of the property boundaries

c) Describe the existing site conditions and the proposed project

2) **Field Investigations**

a) Test borings must be drilled to determine the subsurface geology. There should be a minimum of four test borings located outside the perimeter of the proposed project. There should be at least one boring in the center of a proposed project. These borings must de drilled at least 10 feet deeper than the proposed depth of an excavation or to the existing groundwater table. The borings should be completed as temporary observation wells. The locations of these borings must be clearly shown and labeled on the site topographic map. Descriptive logs for each boring should be prepared by a qualified professional using the Unified Soil Classification System (USCS) to describe the subsurface soil and sediment. The boring logs must contain the following:

- Boring name
- Land surface elevation
- Depth of boring
- Description of different sediments encountered to the bottom of the boring
- Construction details for the temporary observation wells
- Top of casing elevation
- Depth to water
- Elevation of water in the well

b) Install monitoring wells near the perimeter of the site and outside of any proposed excavation or construction. If more than one aquifer is encountered in the test borings, separate wells should be screened in each aquifer to determine the vertical head gradient. Include monitoring well construction logs in the report appendix.

c) Water levels in the monitoring wells and all nearby wetlands, streams, and lakes should be measured and related to a common site datum. Show all water level measurements and elevations on a map and in the report table.

d) Residential wells within a one-mile radius of the site should be inventoried and located on the map (item 1d above). Include all well logs in the report appendix.

3) **Data Analysis**

a) Prepare a contour map of the water table elevations, including water-level measurements from nearby wetlands, streams, and lakes. Show the site boundaries.

b) Prepare a map showing the location of investigation cross-sections.

c) Prepare multiple cross-sections passing through the proposed project and all areas of concern (wetlands, streams, lakes, residential wells, etc.) to a distance of approximately 1 mile beyond the site boundaries. On these cross-sections, show the following:

- Vertical and horizontal scale
- Existing land surface elevations
- Boundaries and depth of any proposed excavation
- Well locations and logs used to prepare the cross-sections
- Thickness and extent of the subsurface geologic strata
- Location and depth of all residential wells, wetlands, streams, and lakes falling on the cross-section

d) Analyze the impact on nearby surface water and groundwater resources if the project involves de-watering the site. This may be any appropriate method of analysis, which would include

either analytical or numerical modeling methods. It is up to the consultant to justify the selection of the analysis methodology. An analytical model or superposition numerical model may be the most appropriate methods since we want to assess the change in water levels, not necessarily simulate the hydrologic cycle for an entire watershed.

e) Conduct an analysis of the impact of the project on nearby surface water, including wetlands and groundwater resources. Discuss the difference between the existing and post-construction conditions. In the existing condition, rain falls on the ground and some runs off, some is lost by evaporation from soils or transpiration from plants, and the rest infiltrates to the underlying aquifer. After construction, the rain falls primarily on an open water surface. There is no surface runoff and no transpiration from plants, only evaporation from an open body of water. The rest infiltrates to the underlying aquifer, if vertical gradients are downward. The consultant should make an assessment of the net change in water loss in the area of the project. If there is a net increase in water loss, this rate should be used as a stress on the aquifer, analogous to a pumping well. A simple well hydraulics or analytical model may be used to approximate the water-level decline at various distances from the center of the project ; numerical modeling is not expected to be required.

f) If the project will only create or enlarge an excavated lake, the primary impact will be caused by increased evaporation from the new or increased lake surface. This impact can usually be evaluated through a water budget analysis. The LWMD has a draft guidance document for how to perform this analysis that can be downloaded at http://www.michigan.gov/documents/deq/lwm-waterbudget_202791_7.pdf

g) If multiple aquifers are encountered during test drilling activities, and the proposed bottom of the project will completely penetrate an intervening confining layer, the analysis becomes more complicated. An examination of groundwater level data from the monitoring well clusters will determine whether there will be a negative impact on either aquifer. If water levels in the deeper aquifer are lower than the upper aquifer (as in a groundwater recharge area), breaching the confining layers will create a conduit through which groundwater from the upper aquifer will drain into the lower aquifer. There will be a permanent lowering of the water table in the vicinity of the project, potentially draining nearby wetlands or ponds, or lowering water levels in nearby residential wells. If water levels are higher in the lower aquifer, the opposite will happen - water levels in the upper aquifer will rise, while those in the lower aquifer decline. The degree and extent of decline in either case will depend upon the hydraulic properties of the aquifers and the rates of groundwater recharge and lateral groundwater inflow from surrounding areas. An analysis of this type of problem would require a numerical model.

h) Prepare maps and cross-sections showing the extent of the impact (e.g. water-level decline); do not simply map the water table elevations.

i) Show all supporting documentation for sources of data, data analysis calculations, model input data sets, and model output. Do not fill report appendices with arrays of numbers from numerical model input and output data sets. Provide numerical model data sets in digital format.

4) **Investigation report**

The data in this report should document existing site conditions and be made a part of the permit application file. The report should be provided to the LWMD for review prior to issuing a permit. This report will contain the following elements:

- An introduction describing present land use and the relationship of the site to surrounding properties. Use either the site location or a topographic map, whichever is more appropriate.
- A discussion of the proposed project and schedule, along with the intended future use of site. Use a topographic map showing proposed extent of the project and different phases, if applicable.
- A presentation of measured water levels as a contour map of the water table that also shows the groundwater flow directions
- A discussion of groundwater and surface water movement through the area. Use either the site location or a topographic map, whichever is more appropriate
- A presentation of the results of test boring work as cross-sections through the proposed project area showing land surface elevation, surface water features (if applicable), the proposed extent of any excavation, and the subsurface soils and sediments encountered in the test borings.
- A conclusion discussing the expected impact to the hydrologic characteristics of the local area

5) **Additional work**

It may be necessary to require additional work at the site. Items to look for are, but not limited to, the following:

- Surface water diversions – There may be existing surface water bodies or wetlands located on-site or very near the proposed project. With this situation, there is the potential for water to be diverted toward an excavation and away from the existing surface water bodies or wetlands. Additional investigations may be needed to demonstrate that no diversion of surface water will take place. It may be necessary to modify the design to insure that a topographic divide exists between the project and the surrounding surface water bodies.

- Groundwater diversions - There may be instances where multiple aquifers are encountered by the test borings. If this is the case, it is necessary to have temporary wells screened in each aquifer that is expected to be penetrated by an excavation. It is necessary to measure hydraulic head (water level elevation) in each well to determine whether there are vertical differences in head between aquifers. If there are vertical head differences, groundwater will move into an excavation from aquifers having higher head, possibly draining this aquifer. As an example, if there is a perched aquifer with a connected wetland and an underlying aquifer with a lower head, groundwater could drain from the perched aquifer and wetland to the underlying aquifer if an excavation penetrates the impermeable layer under the perched aquifer. Water levels in this aquifer and wetland may lower as a result. If there is an underlying aquifer with a higher head, groundwater will flow from this aquifer to the excavation. This may result in a lowering of heads in this aquifer. If there are flowing wells screened in this aquifer or springs associated with this aquifer, heads may be lowered sufficiently to stop the flow of water from the well or spring.

- Water quality impacts – It may be possible to impact the quality of existing surface-water bodies if the chemical quality of water in the excavation changes as a result of land use practices around the excavation. For this to occur, there must be a surface water connection or significant groundwater connection to the surface-water body. The risk to surface-water quality may be reduced by adopting land use practices which don't impair the water quality in the excavation and reducing, or eliminating, any surface-water connection to nearby surface-water bodies.